CALFED

TECHNICAL REPORT
ENVIRONMENTAL CONSEQUENCES

SUPPLEMENT TO SURFACE WATER RESOURCES

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BAY-DELTA
PROGRAM

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The output from DWRSIM includes calculated monthly flow volumes in thousands of acre-feet that passes a control point defined in the model. These volumes can be converted to an average monthly flow rate (discharge), expressed in cfs. With a few exceptions, the control points generally represent locations within the storage and conveyance system. Typically, the control points are where diversions, storage, downstream flows, regulatory required flows, or tributary inflows need to be adjusted or evaluated. DWRSIM also contains a module to calculate the X2 location in the Delta Estuary.

For existing conditions, DWRSIM simulates the storage and conveyance facilities as they existed in 1994. The operating assumptions are based on the SWRCB base study 469, which includes D-1485 Delta standards, CVPIA flow criteria, the 1995 WQCP standards, and Endangered Species Act requirements. The simulation of existing conditions reflects how available water from October 1921 through September 1994 would have been allocated. (This same set of hydrologic inputs is used in simulations of alternative configurations to study the potential effects for a reasonably wide range of inflows.) The results of these simulations are discussed further in the sections on the Sacramento River and San Joaquin River regions.

One advantage of using DWRSIM is that it allows users to test the response of the system to the entire range of inflows that have occurred historically. The hydrologic input to the DWRSIM model is based on the actual record of precipitation and runoff for water years from 1922 to 1994. Accordingly, the monthly average discharge rates calculated by the model for each control point are not expected to match the historic record because the historic record reflects the configuration and operation of the storage and conveyance system that existed historically, and not the conditions in 1994.

The modeling of the Delta using DWRDSM1 includes hydrodynamics (flows, velocities, and stages), mass tracking studies, and salinity modeling. The hydrodynamic modeling was performed using 16 years of monthly average hydrologic data (October 1975 to September 1991) from DWRSIM study 1995C06F-SWRCB-469. Three months were selected to represent various flow conditions in the Delta: March 1983, representing high inflow conditions; October 1989, representing low inflow/high pumping conditions; and July 1991, representing low inflow/low pumping conditions. DWRDSM1 output included monthly average, minimum, and maximum tidal flows, velocities, and stages for each channel in the modeling network. A subset of the channels was analyzed in this report.

The mass tracking studies were performed for selected locations within the Delta. Mass was continuously released at a particular location and tracked to determine its eventual fate in the Delta. Injection locations included the Sacramento River at Freeport, the San Joaquin River at Vernalis, Terminous, San Andreas Landing, Prisoners Point, the Sacramento River at Rio Vista, and the San Joaquin River at Jersey Point. The fate of released mass was monitored at the following locations: Contra Costa Canal, export locations, Delta islands, Delta channels and waterways, and Chipps Island. Four months were selected for mass tracking analysis based on fish and wildlife concerns: February 1979, representing high inflow/high pumping conditions; April 1991, representing medium inflow/low pumping conditions; October 1989, representing low inflow/high pumping conditions; and July 1991, representing low inflow/low pumping conditions.

Salinity modeling also was performed for key locations within the Delta. Monthly minimum, maximum, and average tidal-day salinity was simulated for the entire 16-year period. Four locations were selected to represent existing conditions: Emmaton, Jersey Point, Old River at Rock Slough, and Clifton Court Forebay.

Bay-Delta Hydrodynamics and Riverine Hydraulics

DEVELOPMENT OF RATING CURVES FOR HYDRAULIC PARAMETERS AT SELECTED CONTROL POINTS IN THE SACRAMENTO AND SAN JOAQUIN RIVER SYSTEMS

Measurements of gage height, average velocity, stream width, and channel cross-sectional area were obtained from the USGS for the period 1967 to 1997 for selected stream gage locations. Gage height is the height of water in the stream, in feet, measured in a gage set at a fixed depth in the stream channel, usually the deepest point. The gage height can be converted to the corresponding elevation of the water surface by adding the gage height to the elevation of the gage datum. Average stream velocity is a calculation based on a number of measurements, and is reported in units of fps by the USGS. The stream width is the width, in feet, of the wetted portion of the channel. The cross-sectional area of the channel, in square feet, is determined from soundings along the stream cross-section. The average stream depth is a calculated value, determined by dividing the cross-sectional area by the stream width.

It has been observed that in natural, graded streams, average stream depth, average velocity, and stream width tend to follow a relation to discharge of the form $y=ax^b$, where "y" is the average stream depth, average velocity, or stream width; "x" is the discharge, and "a" and "b" are constants. The relation does not necessarily hold in engineered stream channels, where the bed of the stream is not able to adjust naturally to discharge.

It was desired for this study to find mathematical expressions that would allow conversion of simulated discharge values to depths, velocities, and stream widths that would reasonably approximate observed values over the range of the observed values. Figures S-1 through S-12 show the measured and calculated data, and the plots of the equations that were found to fit the data reasonably well. The equations are shown on the graphs were used to calculate the estimated values of depth, velocity and stream width used in the river hydraulics study. In most cases, a single equation fit the data adequately, but in some cases, two, or even three equations were needed to adequately fit the data. Data from most of the study locations could be reasonably approximated by one to three power equations of the form y=axb, but linear equations of the form y=ax + b were used to fit the depth and width data for the Feather River near Gridley (Figure S-8; USGS Station No. 11407150).

The data for some parameters at some of the stations indicate an abrupt change in the value of the dependent variable over a narrow range of discharge. For example, discontinuities appear to occur at about 40,000 cfs and about 105,000 cfs in the depth and width graphs for the Sacramento River above Bend Bridge (Figure S-6, USGS Station No. 1137100). The discontinuities suggest that the channel geometry changes at the elevations corresponding to the river stage at these discharges. Flood stage occurs in the range of about 40,000 cfs (27 ft.)

at this station. The variability in the width and average depth measurements shown in Figures S-6b and S-6d probably reflect the difficulty in measuring the hydraulic parameters as the river exceeds flood stage and widens rapidly as it flows onto the floodplain above the main channel.

Gage height data at some of the stations were adjusted by a constant before fitting the data with a power equation to achieve the best correlation to the data. The rationale for doing this is that the when discharge is zero, average stream depth must also be zero. In practice, the zero point on the gage does not necessarily correspond to the depth at which discharge is zero. By adjusting the gage height values by a constant value, the resulting fit of the power curve to the data could generally be improved. The constant is then subtracted from the intermediate calculated values to obtain the estimated gage heights for the station. The data plotted on the graphs show the fit obtained for the intermediate values, and would need to be readjusted by the constant to reflect the estimated gage height.

Table S-1 shows the resulting coefficients for each of the gage stations. Coefficients for multiple curves are provided when needed. The table also includes the station name, period of analysis, elevation datum of the gage, and the range of discharge within the equations are assumed to be valid.

TABLES AND FIGURES FOR THE SUPPLEMENT

Table S-1 Coefficients and Exponents for Calculating Stream Velocity, Depth, and Width

USGS Station	Description	Period used for analysis	Elevation Datum	Flow Range	Stage			Depth Correction	Flow Range	Average Depth			Flow Range	Width			Flow Range	Velocity		
				(cfs)	coef	exp	R^2		(cfs)	coef	exp	R^2	(cfs)	coef	exp	R^2	(cfs)	coef	exp	R^2
11446500	American River at Fair Oaks	1987-95	71.53	0 - 120,000	0.055	0.52	0.98	-3.1	0-120,000	0.30	0.36	0.75	0-120,000	110	0.14	0.62	0-40,000	0.028	0.52	0.80
"	"	"	"														40,000-120,000	0.30	0.29	1.00
11370500	Sacramento River at Keswick, Boards In	1973-97	479.81	0 - 19,000	0.71	0.35	1.00	5.0	0 - 19,000	2.0	0.15	0.59	0 - 19,000	453	0.028	0.15	0 - 19,000	0.001	0.82	0.96
"	Sacramento River at Keswick, Boards Out	1973-97	479.81	0 - 82,000	0.71	0.35	1.00	5.0	0 - 20,000	0.30	0.32	0.81	0 - 30,000	127	0.15	0.77	0 - 30,000	0.031	0.51	0.98
"	"	"	"						20,000-82,000	0.13	0.41	0.94	30,000-82,000	36	0.27	0.73	30,000-82,000	0.16	0.35	0.96
11377100	Sacramento River above Bend Bridge	1988-97	285.77	0 - 135,000	0.14	0.48	1.00	7.0	0-40,000	0.00	0.77	0.99	0-40,000	149	0.10	0.75	0-135,000	1.21	0.15	0.93
"	"	"	"						40,000-105,000	0.72	0.28	0.58	40,000-105,000	0.68	0.62	0.78				
"	"	"	"						105,000-135,000	0.00	0.84	0.88	105,000-135,000	24	0.34	1.00				
11389500	Sacramento River at Colusa	1987-97	-2.95	0-46,000	0.029	0.66	0.99	-33	0-10,000	0.04	0.61	0.83	0-46,000	88	0.13	0.66	0-46,000	0.22	0.28	0.83
"	"	"	"						10,000-46,000	0.06	0.57	0.93								
11389000	Sacramento River at Butte City	1987-95	-2.92	0-105,000	0.045	0.56	0.99	-64	0-105,000	0.17	0.44	0.98	0-105,000	334	0.04	0.61	0-105,000	0.016	0.53	0.98
11390500	Sacramento River below Wilkins Slough	1987-97	-3.00	0 - 30,000	1.92	0.31	0.99	0.0	0-30,000	0.094	0.54	0.97	0-30,000	52	0.17	0.73	0-30,000	0.21	0.29	0.95
11447650	Sacramento River at Freeport	1989-97	sea level	0-100,000	0.030	0.55	0.43	-100	0-100,000	0.45	0.38	0.93	0-100,000	368	0.05	0.50	0-100,000	0.008	0.55	0.89
11425500	Sacramento River at Verona	1987-97	-3.00	0-100,000	0.11	0.52	0.99	0.0	0-30,000	0.039	0.59	0.93	0-39,000	231	0.08	0.75	0-30,000	0.12	0.32	0.76
"	"	"	"						30,000-100,000	0.23	0.42	0.84	39,000-100,000	7.4	0.41	0.90	30,000-100,000	0.25	0.25	0.66
11302000	Stanislaus River below Goodwin Dam	1989-97	252.83	0 - 7,000	0.060	0.56	0.99	-7.0	0-2,000	0.29	0.38	0.89	0-2,000	40	0.15	0.79	0-2,000	0.086	0.48	0.94
"	"	"	"						2,000-7,000	0.13	0.48	0.99	2,000-7,000	27	0.20	1.00	2,000-7,000	0.28	0.32	0.98
11303500	San Joaquin River at Vernalis	1988-97	sea level	0 - 50,000	0.16	0.49	1.00	-4.0	0-10,000	0.028	0.67	0.98	0-10,000	131	0.09	0.69	0-50,000	0.31	0.22	0.73
"	"	"	"						10,000-50,000	0.029	0.63	0.92	10,000-50,000	101	0.15	0.85				
11274000	San Joaquin River near Newman	1995-97	sea level	0-13,000	0.70	0.36	0.99	-42.0	0-4,000	0.10	0.55	0.73	0-4,000	60	0.15	0.86	0-13,000	0.13	0.33	0.68
"	"	"	"						4,000-13,000	5.35	0.07	0.44	4,000-13,000	1.3	0.60	0.92				
"	"	"	"							linear coef.	intercept									
11407150	Feather River near Gridley	1987-97	-2.91	0-120,000	0.019	0.61	0.98	-73.5	0-55,000	0.00	9.11	0.98	0-55,000	205.29	0.043	0.61	0-11,000	0.00	0.87	0.99
"	"	"	"							linear coef.	intercept			linear coef.	intercept					
"	"	"	"						55,000-120,000	0.00	36.43	0.99	55,000-120,000	0.010	-221.38	0.97	11,000-120,000	0.05	0.44	0.98

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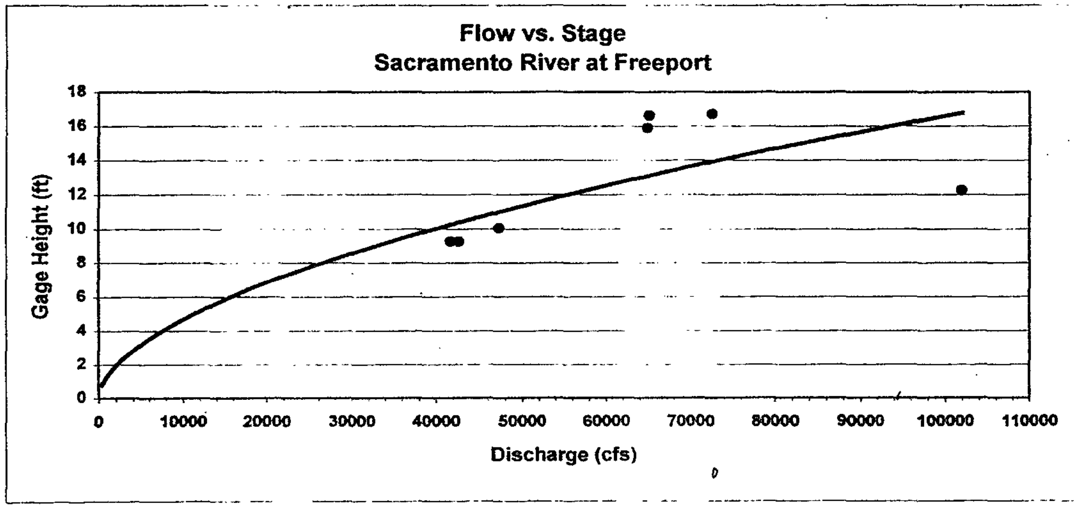

FIGURE S-1a Discharge vs. Gage Height (Measured, 1989-1997)

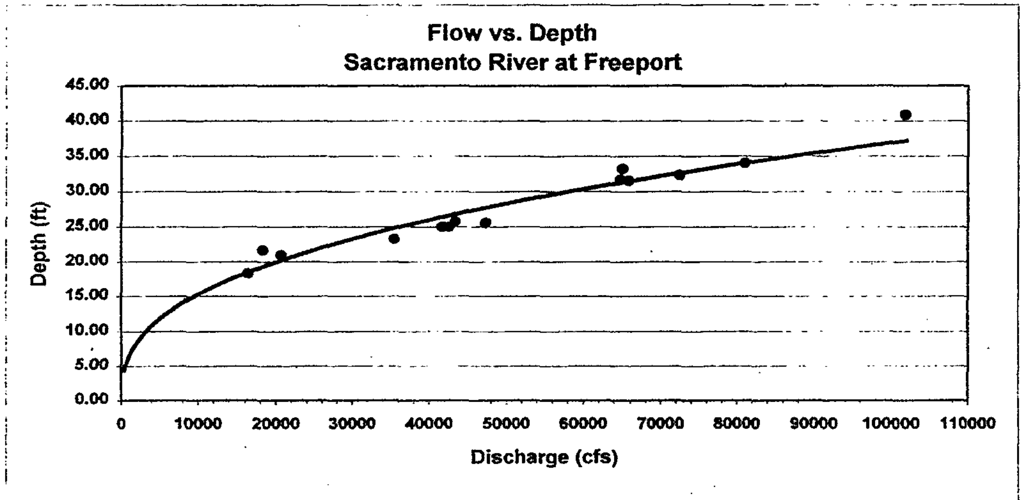

FIGURE S-1b Discharge vs. Average Depth (Calculated, 1989-1997)

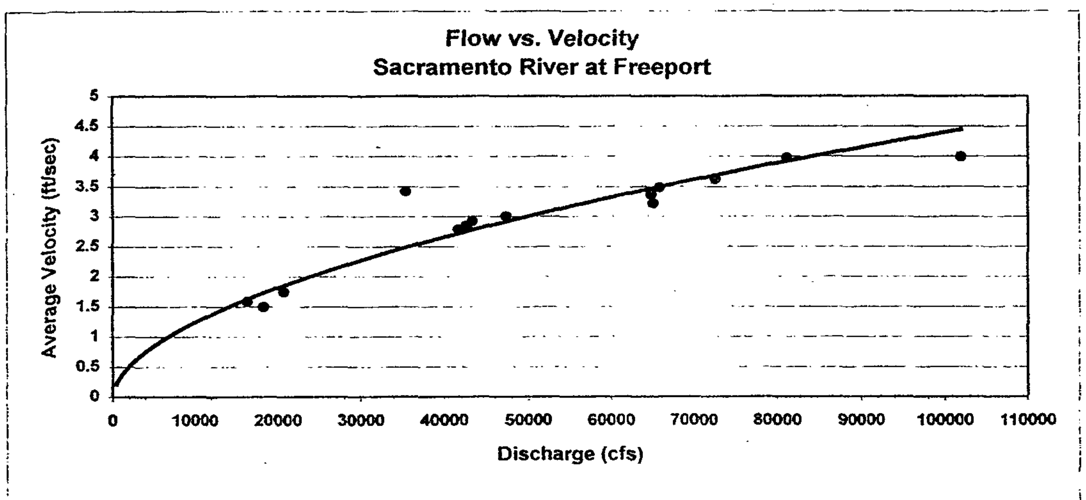

FIGURE S-1c Discharge vs. Average Velocity (Calculated, 1989-1997)

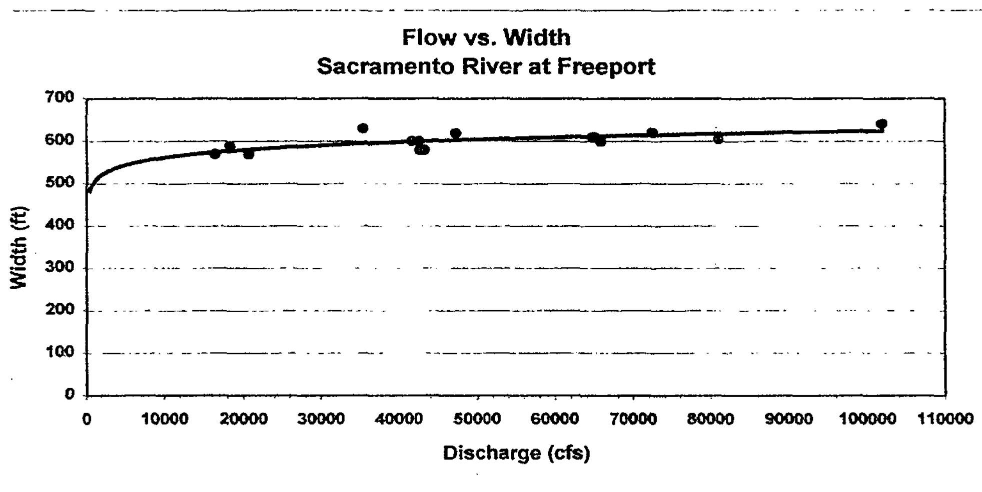

FIGURE S-1a Discharge vs. Top Width (Measured, 1989-1997)

Figure S-1. Sacramento River at Freeport: Flow vs. Stage, Depth, Velocity, and Width

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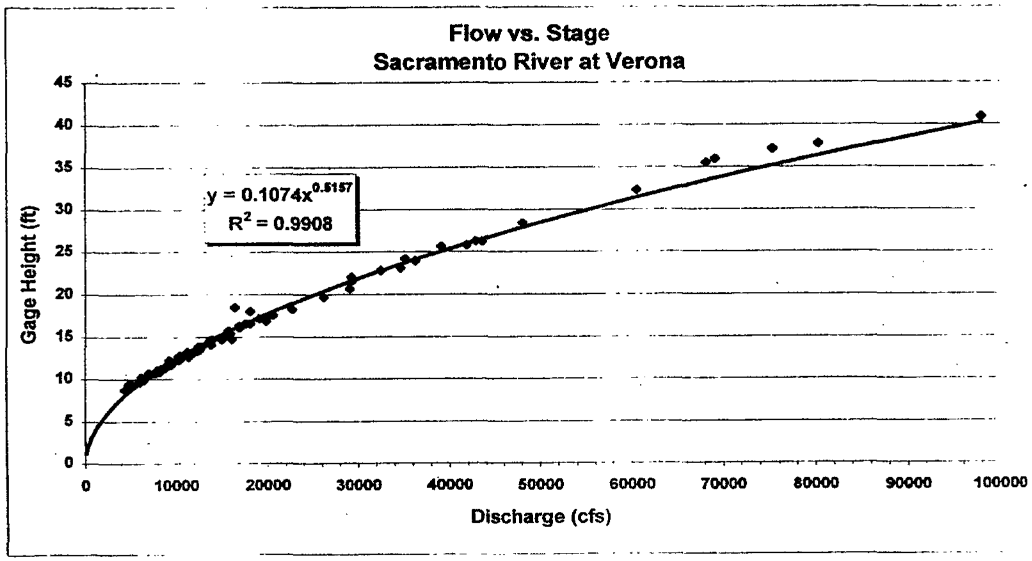

FIGURE S-2a Discharge vs. Gage Height (Measured, 1987-1997)

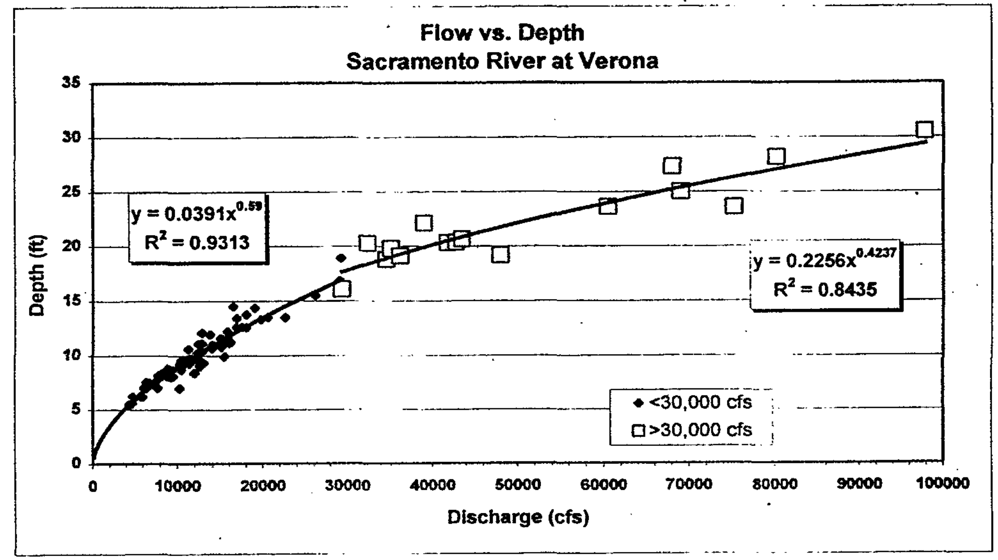

FIGURE S-2b Discharge vs. Average Depth (Calculated, 1987-1997)

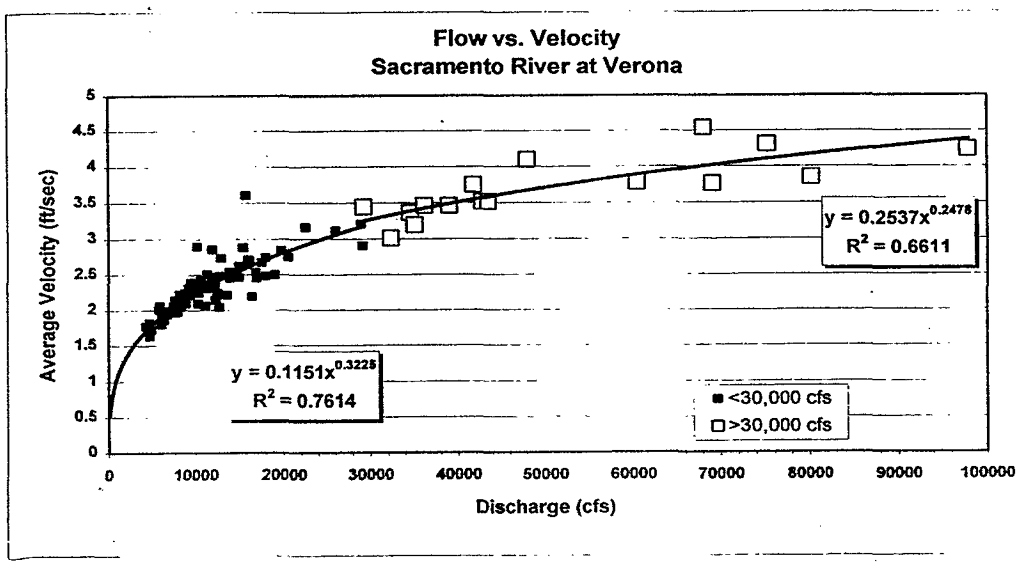

FIGURE S-2c Discharge vs. Average Velocity (Calculated, 1987-1997)

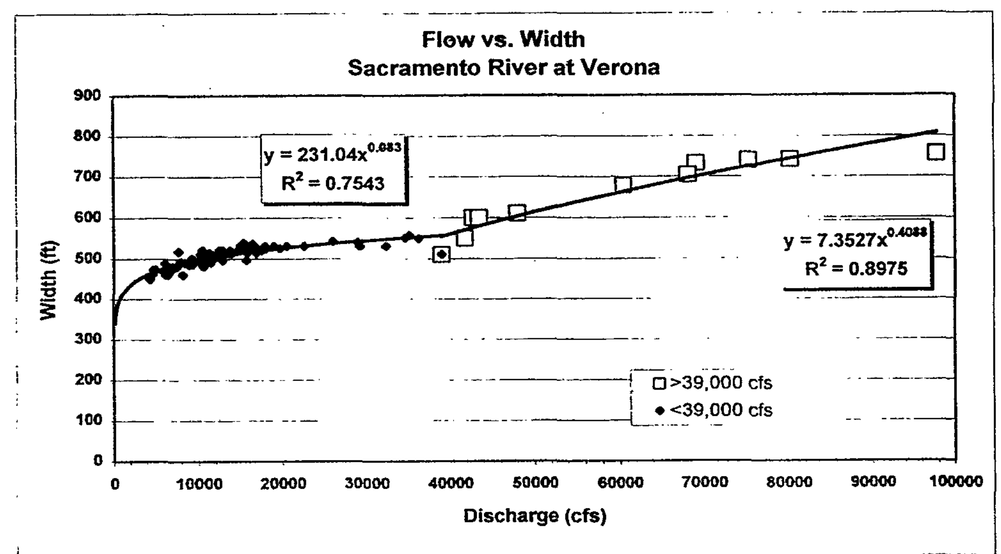

FIGURE S-2d Discharge vs. Top Width (Measured, 1987-1997)

Figure S-2. Sacramento River at Verona: Flow vs. Stage, Depth, Velocity, and Width

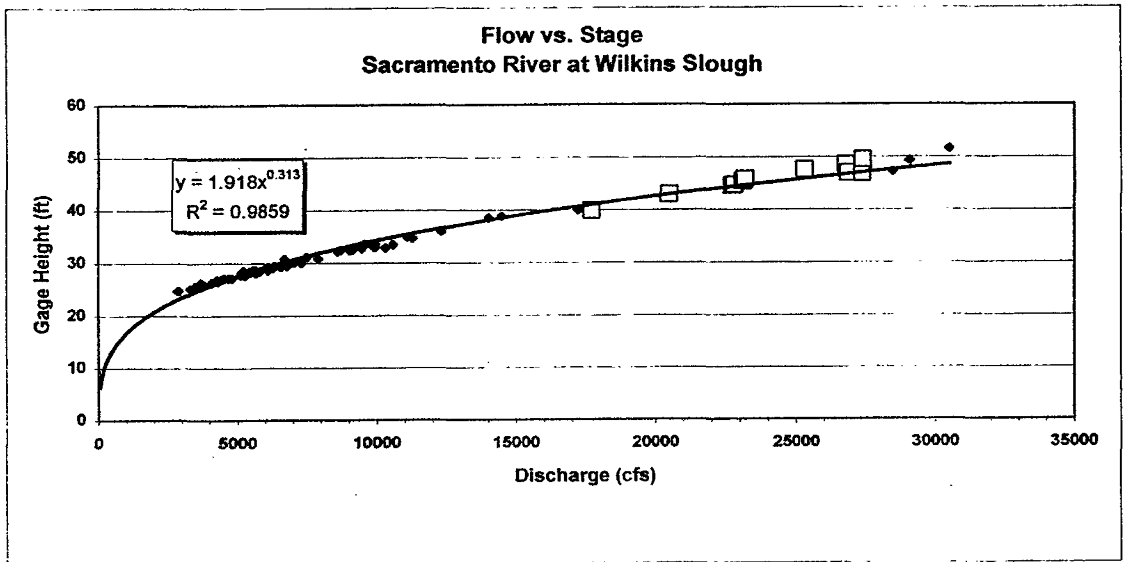

FIGURE S-3a Discharge vs. Gage Height (Measured, 1987-1997)

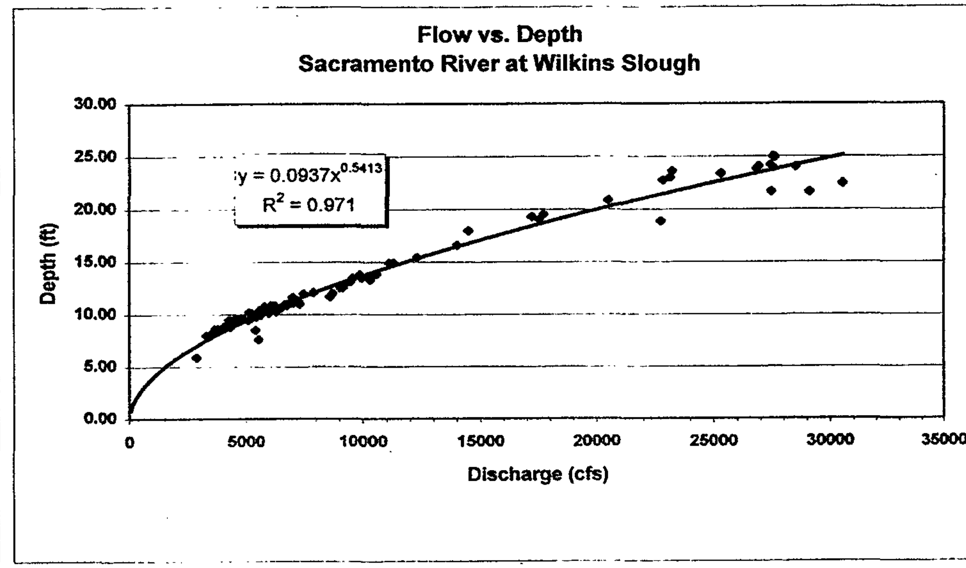

FIGURE S-3b Discharge vs. Average Depth (Calculated, 1987-1997)

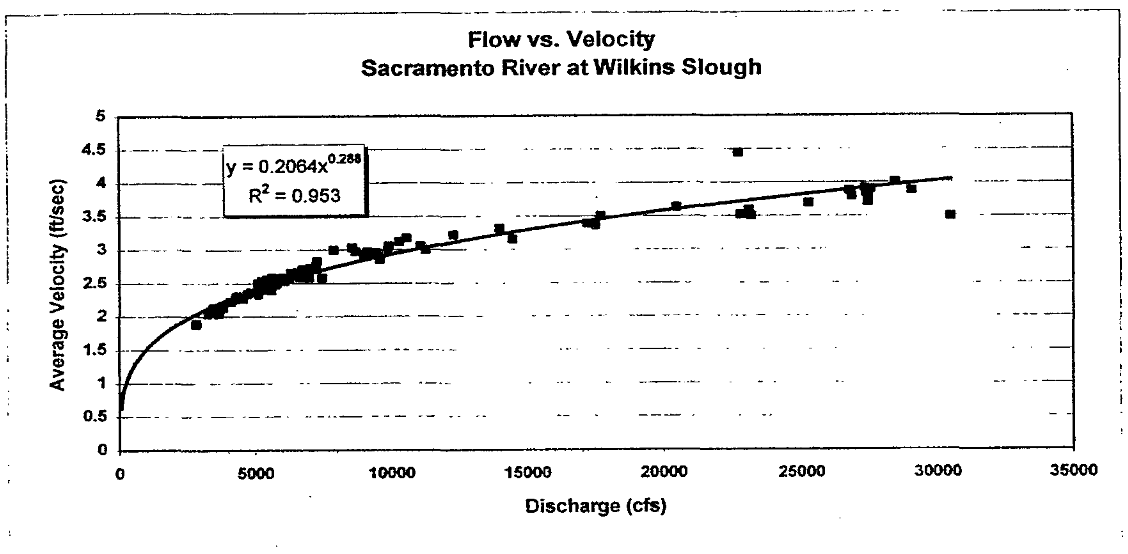

FIGURE S-3c Discharge vs. Average Velocity (Calculated, 1987-1997)

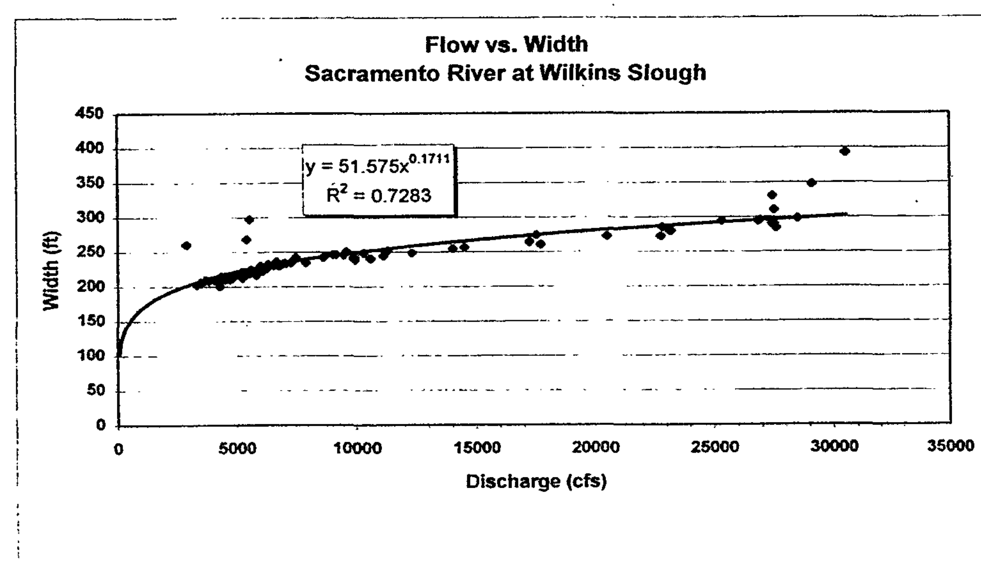

FIGURE S-3d Discharge vs. Top Width (Measured, 1987-1997)

Figure S-3. Sacramento River at Wilkins Slough: Flow vs. Stage, Depth, Velocity, and Width

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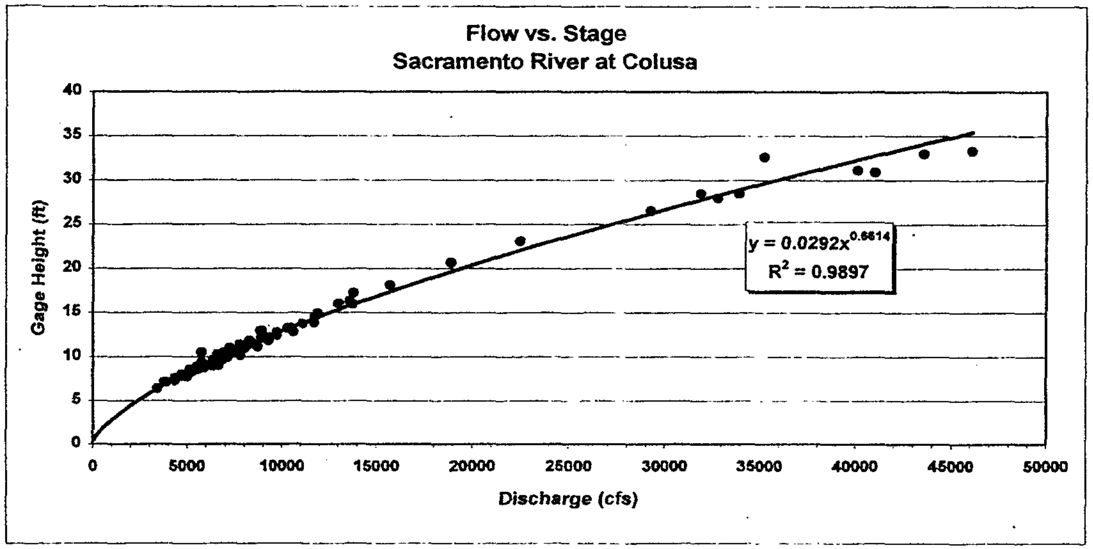

FIGURE S-4a Discharge vs. Gage Height (Measured, 1987-1997)

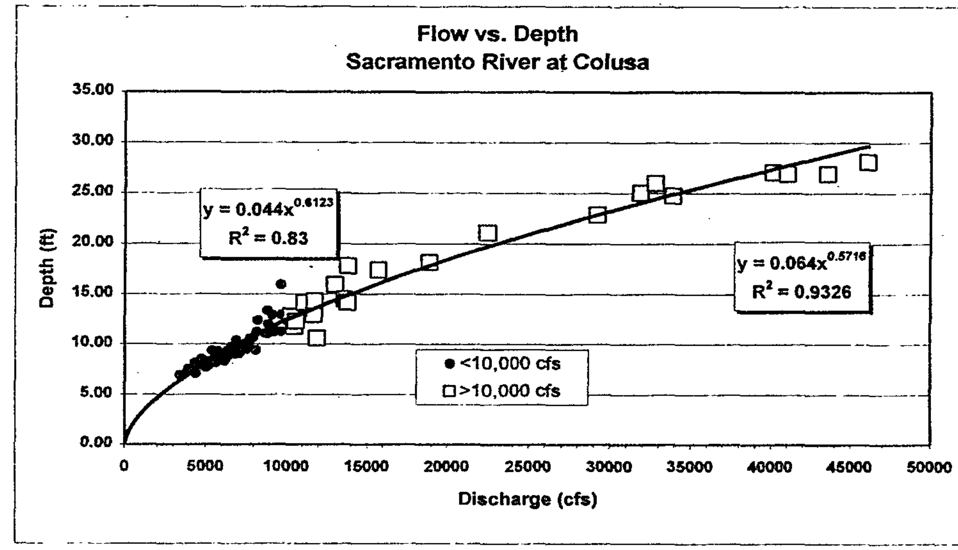

FIGURE S-4b Discharge vs. Average Depth (Calculated, 1987-1997)

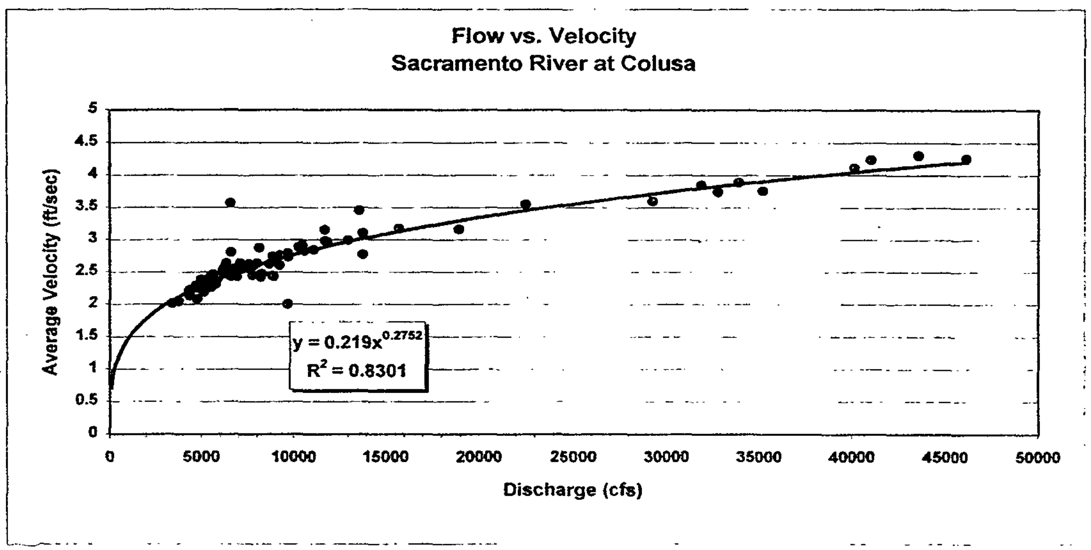

FIGURE S-4c Discharge vs. Average Velocity (Calculated, 1987-1997)

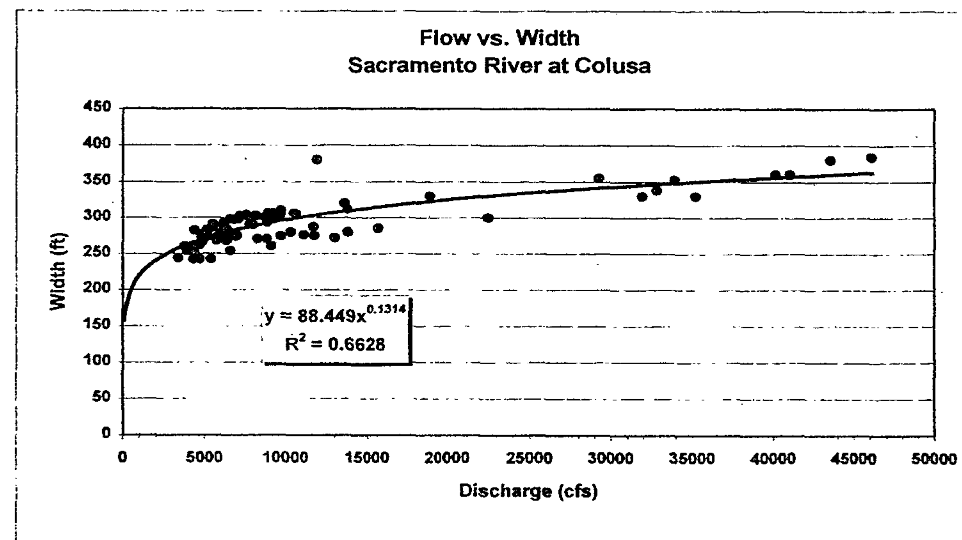

FIGURE S-4d Discharge vs. Top Width (Measured, 1987-1997)

Figure S-4. Sacramento River at Colusa: Flow vs. Stage, Depth, Velocity, and Width

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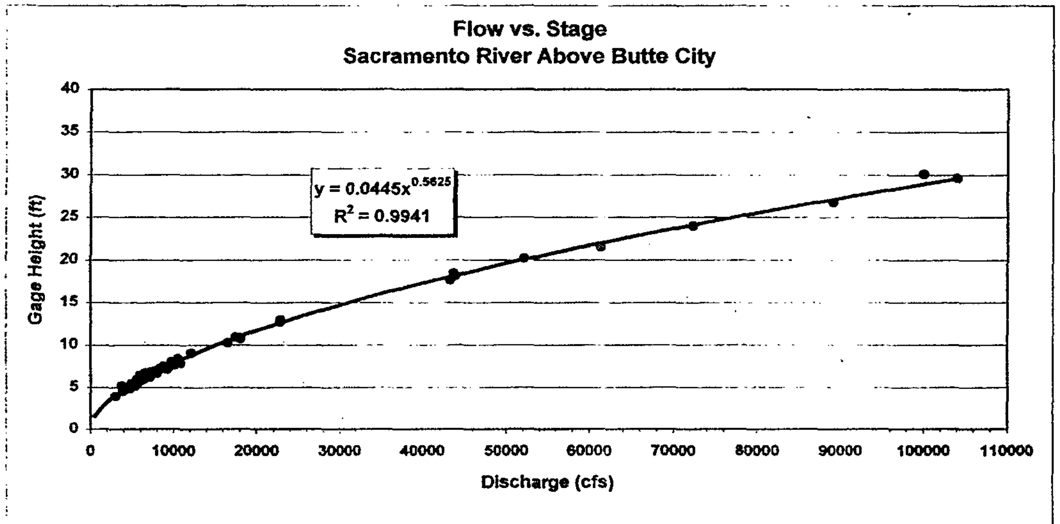

FIGURE S-5a Discharge vs. Gage Height (Measured, 1987-1995)

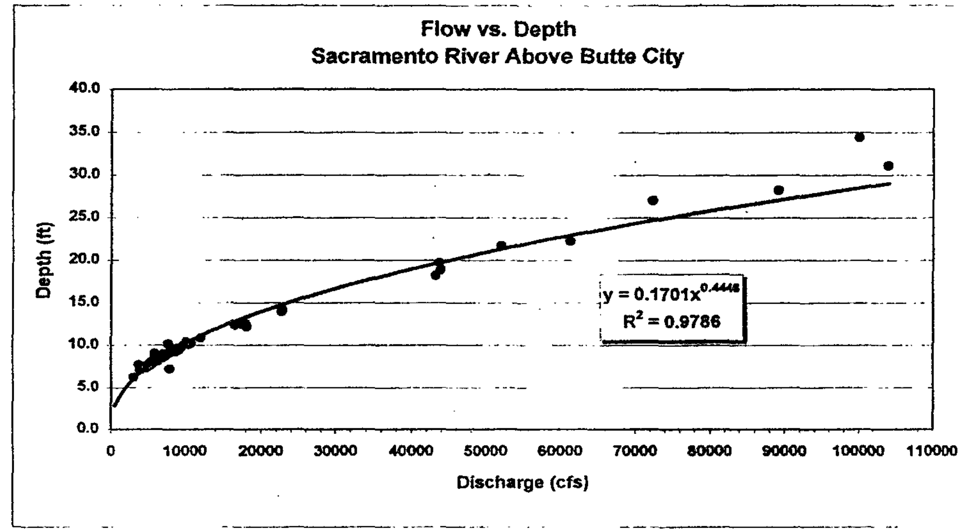

FIGURE S-5b Discharge vs. Average Width (Calculated, 1987-1995)

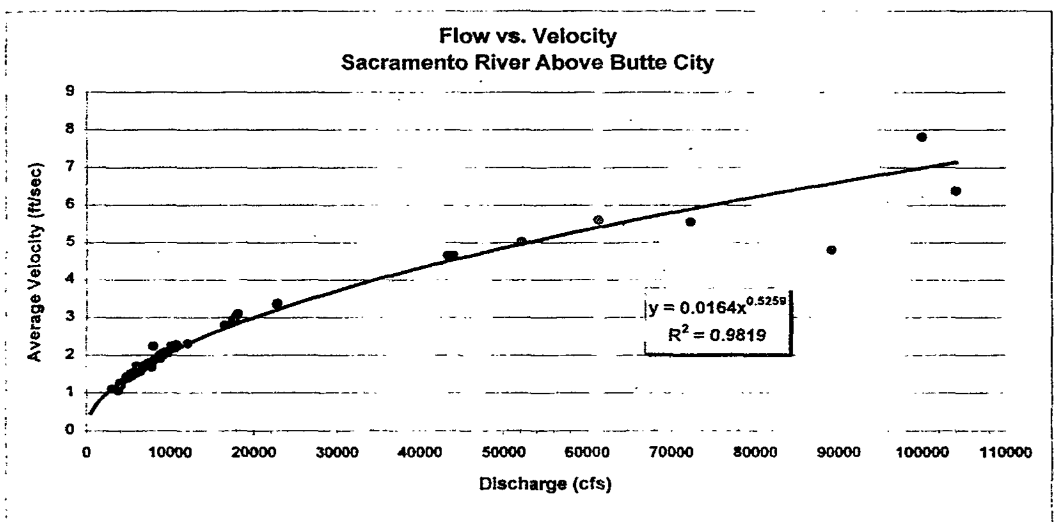

FIGURE S-5c Discharge vs. Average Velocity (Calculated, 1987-1995)

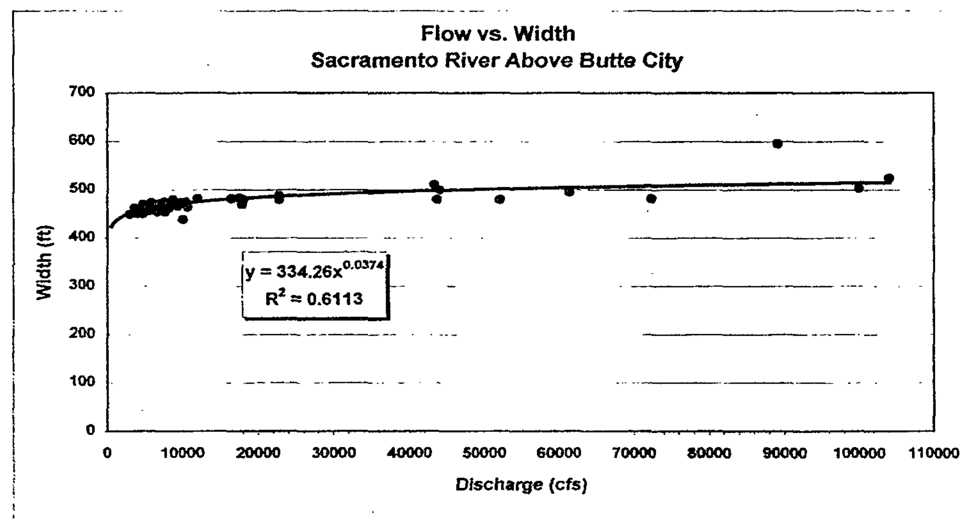

FIGURE S-5d Discharge vs. Top Width (Measured, 1987-1995)

Figure S-5. Sacramento River at Butte City: Flow vs. Stage, Depth, Velocity, and Width

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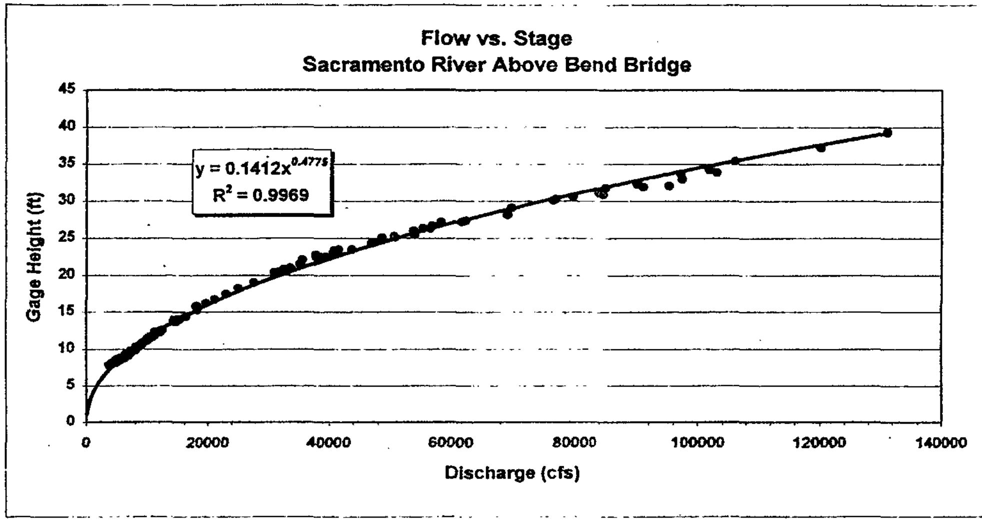

FIGURE S-6a Discharge vs. Gage Height (Measured, 1988-1997)

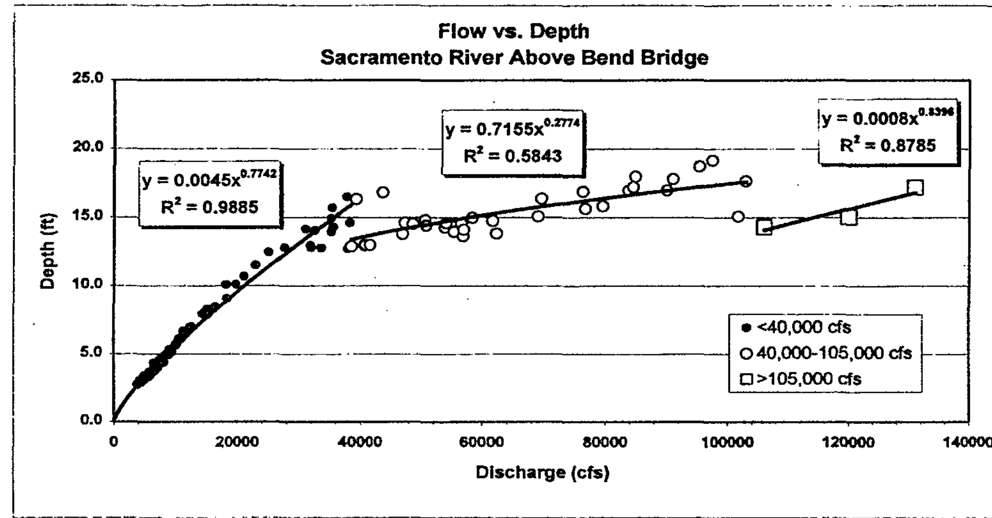

FIGURE S-6b Discharge vs. Average Depth (Calculated, 1988-1997)

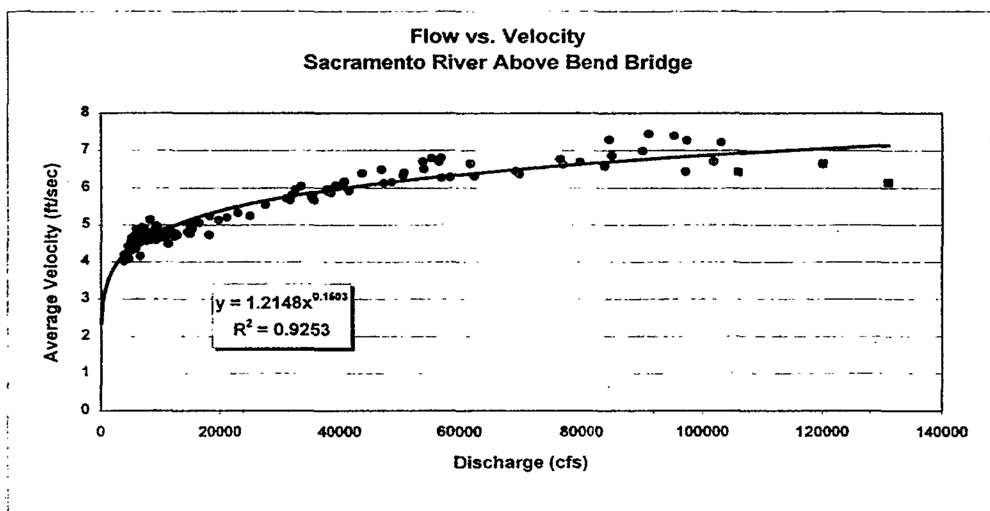

FIGURE S-6c Discharge vs. Average Velocity (Calculated, 1988-1997)

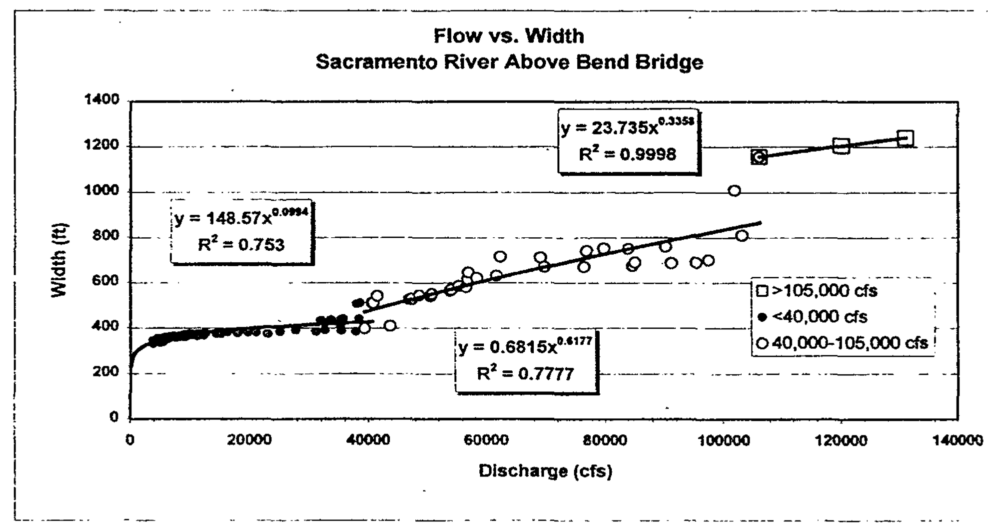

FIGURE S-6d Discharge vs. Top Width (Measured, 1988-1997)

Figure S-6. Sacramento River Above Bend Bridge: Flow vs. Stage, Depth, Velocity, and Width

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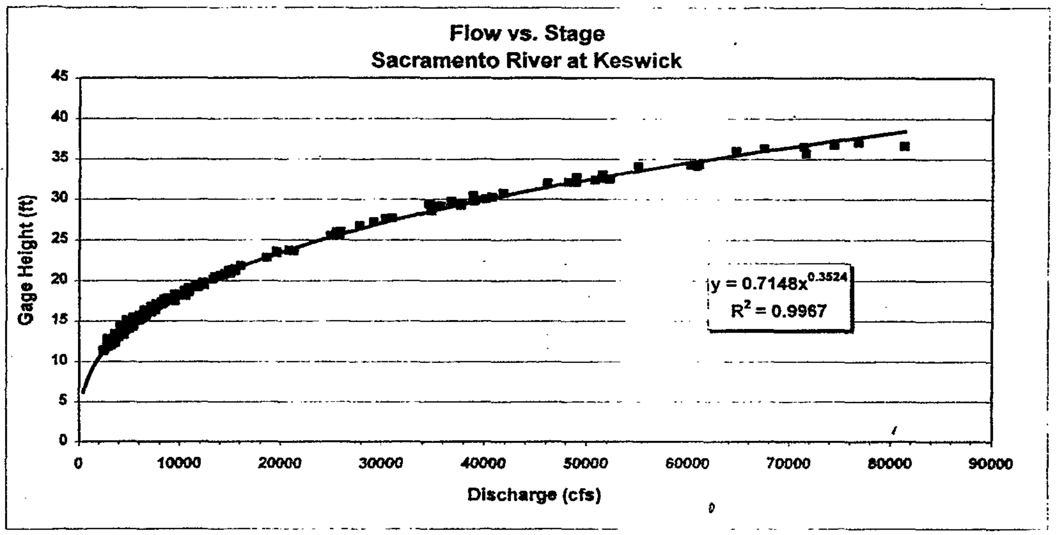

FIGURE S-7a Discharge vs. Gage Height (Measured, 1973-1997)

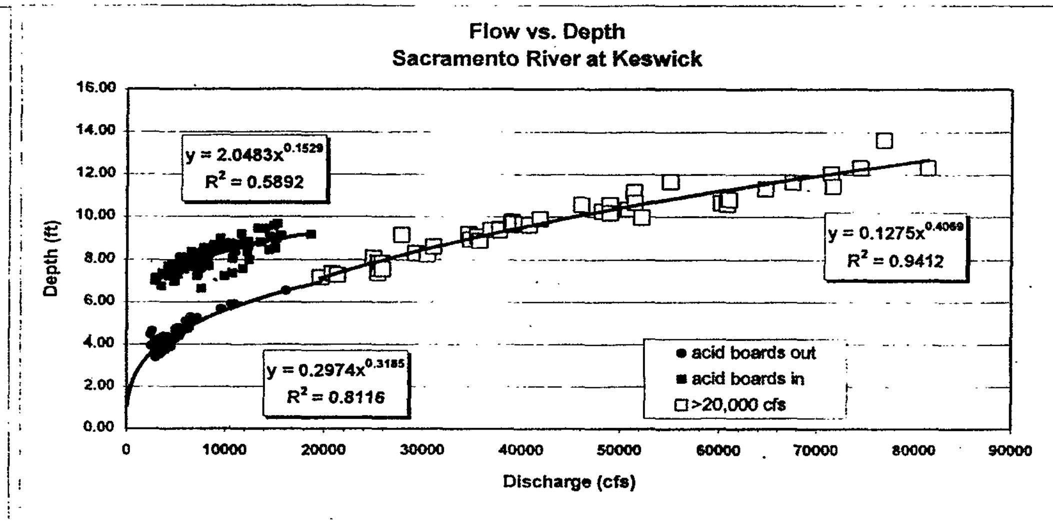

FIGURE S-7b Discharge vs. Average Depth (Calculated, 1973-1997)

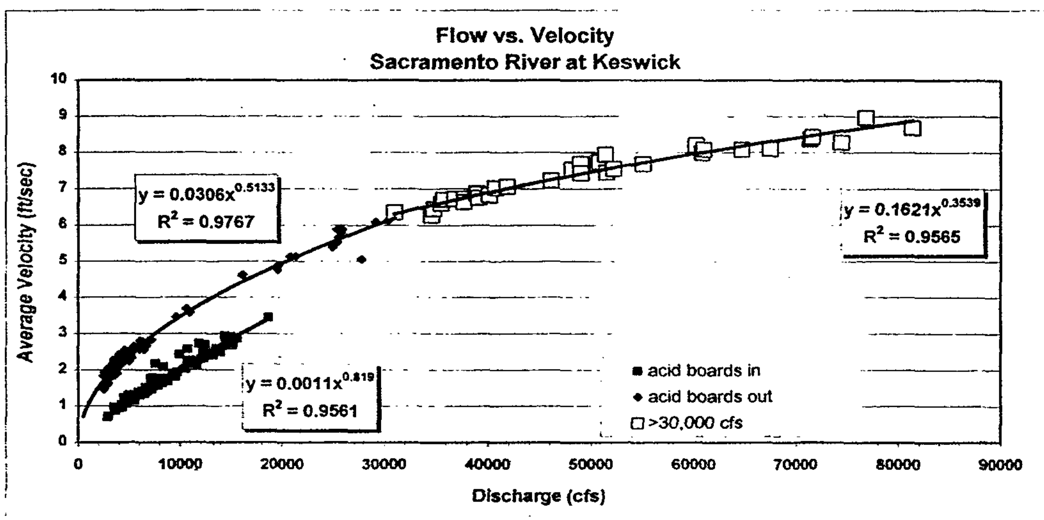

FIGURE S-7c Discharge vs. Average Velocity (Calculated, 1973-1997)

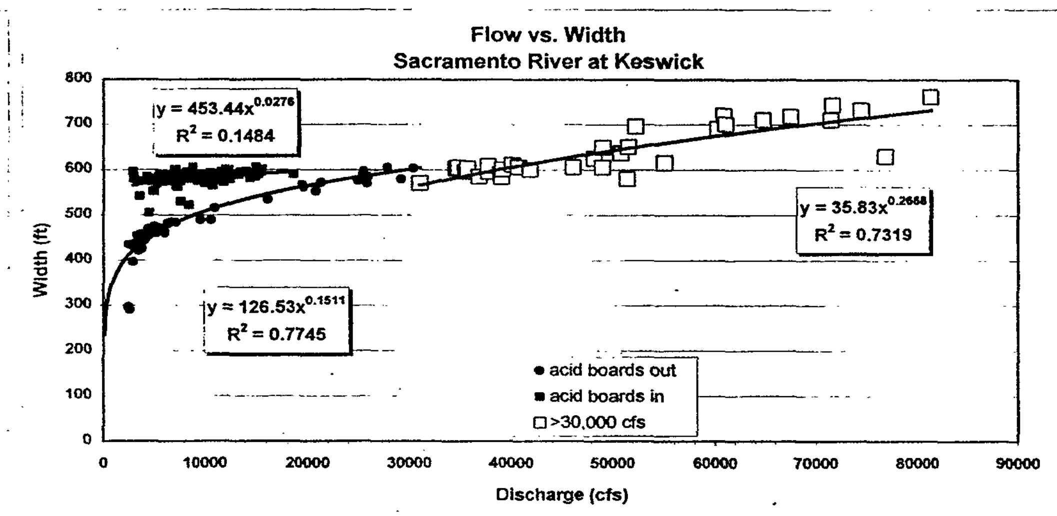

FIGURE S-7d Discharge vs. Top Width (Measured, 1973-1997)

Figure S-7. Sacramento River at Keswick: Flow vs. Stage, Depth, Velocity, and Width

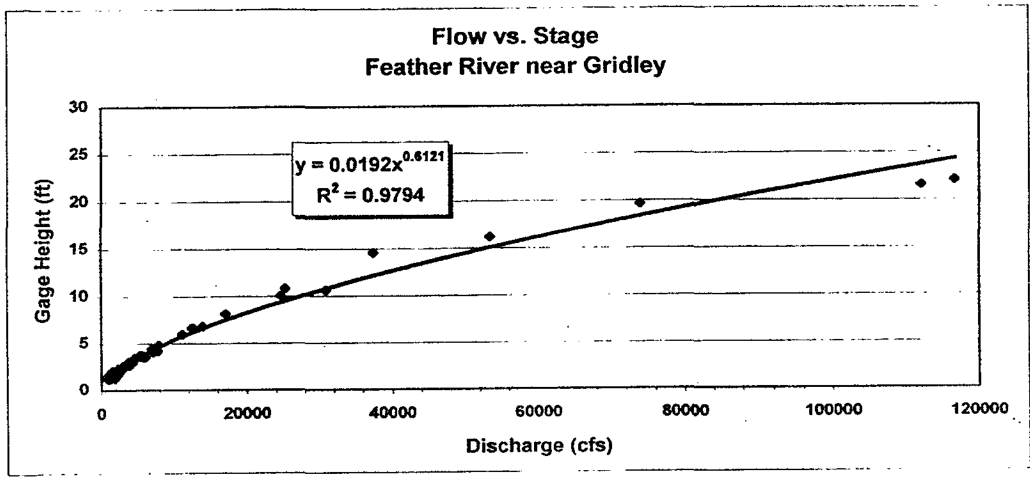

FIGURE S-8-a Discharge vs. Gage Height (Measured, 1987-1997)

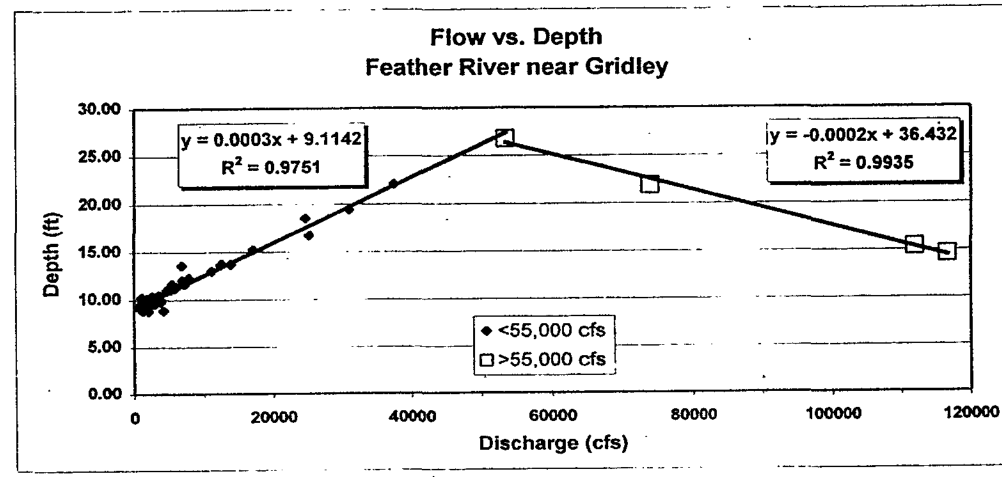

FIGURE S-8-b Discharge vs. Average Depth (Calculated, 1987-1997)

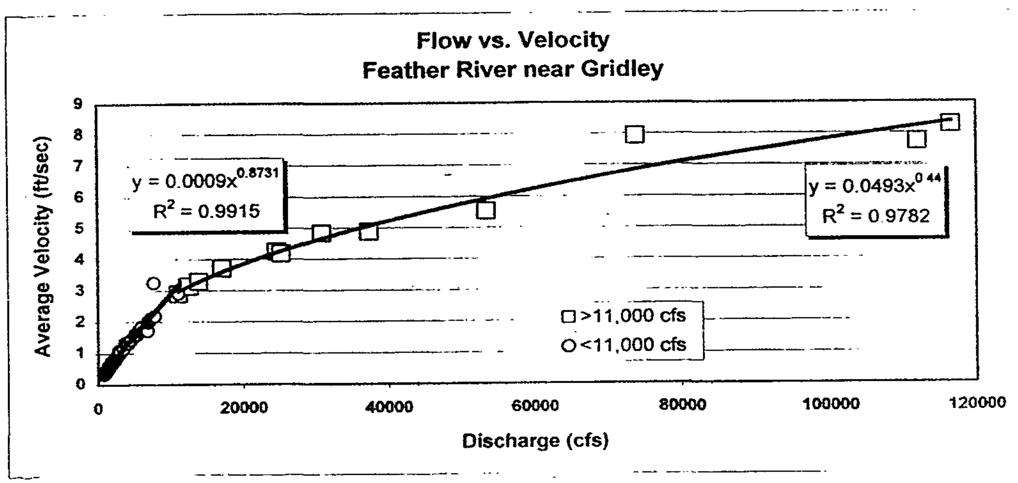

FIGURE S-8-c Discharge vs. Average Velocity (Calculated, 1987-1997)

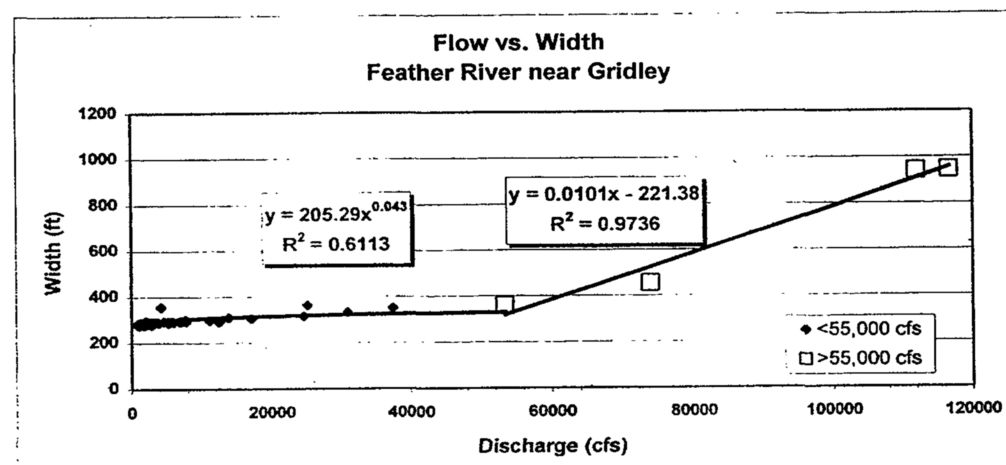

FIGURE S-8-d Discharge vs. Top Width (Measured, 1987-1997)

Figure S-8. Feather River Near Gridley: Flow vs. Stage, Depth, Velocity, and Width

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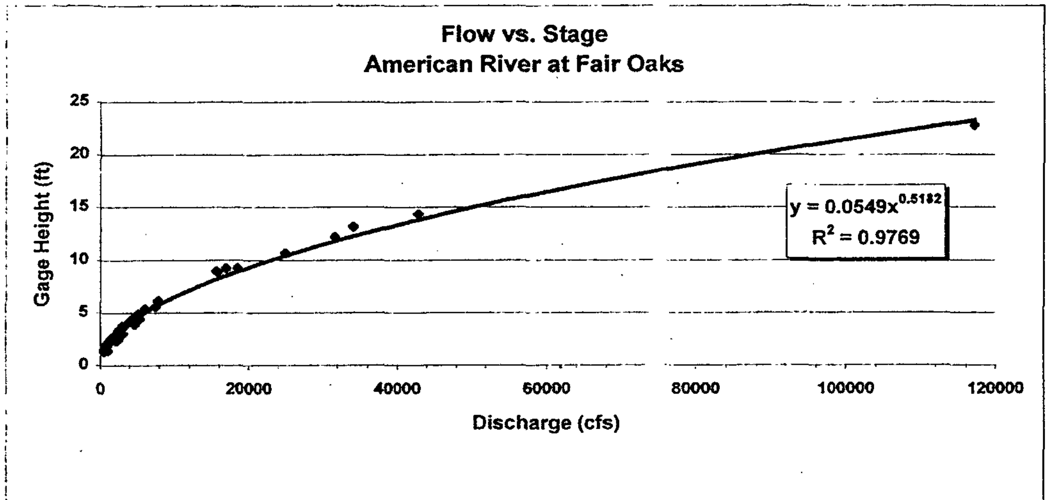

FIGURE S-9a Discharge vs. Gage Height (Measured, 1987-1995)

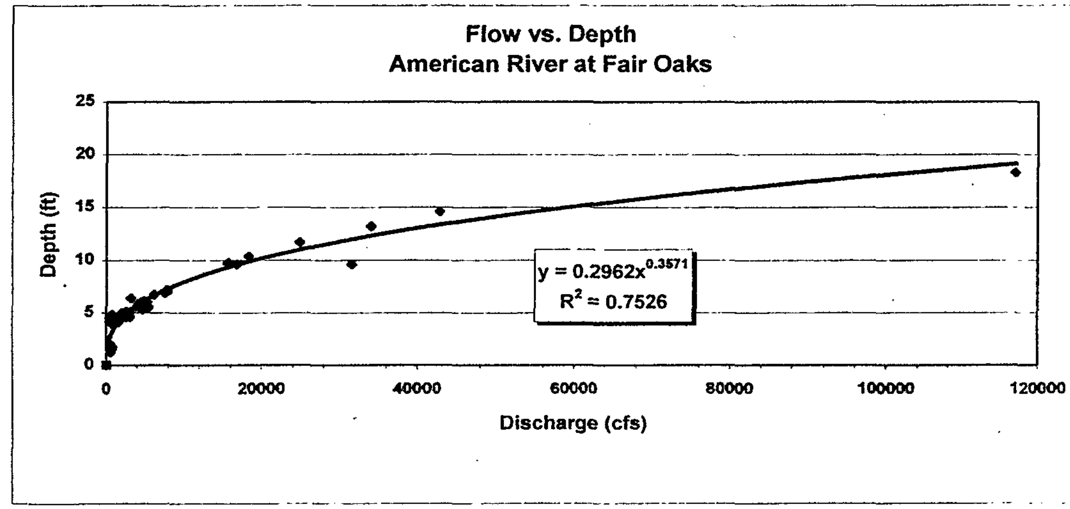

FIGURE S-9b Discharge vs. Average Depth (Calculated, 1987-1995)

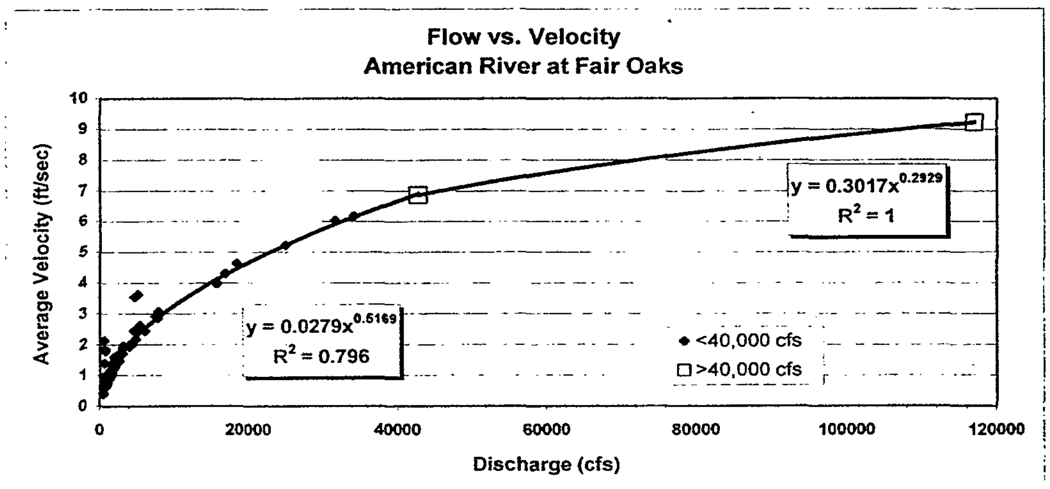

FIGURE S-9c Discharge vs. Average Velocity (Calculated, 1987-1995)

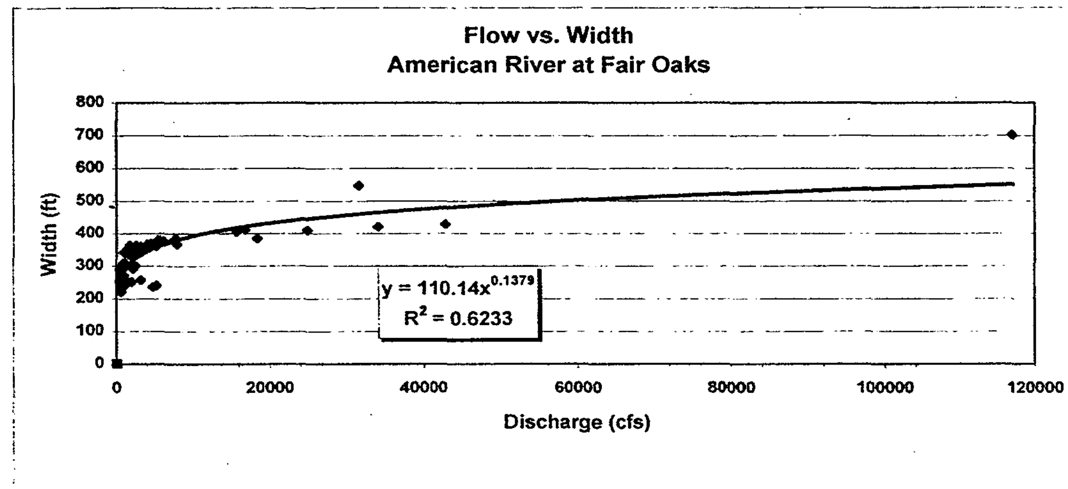

FIGURE S-9d Discharge vs. Top Width (Measured, 1987-1995)

Figure S-9. American River at Fair Oaks: Flow vs. Stage, Depth, Velocity, and Width

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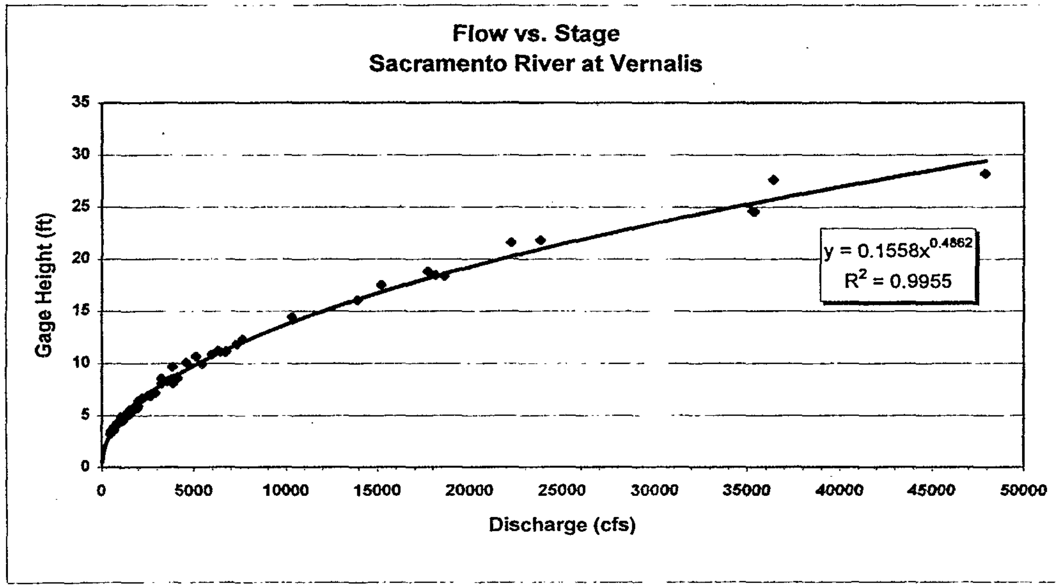

FIGURE S-10a Discharge vs. Gage Height (Measured, 1988-1997)

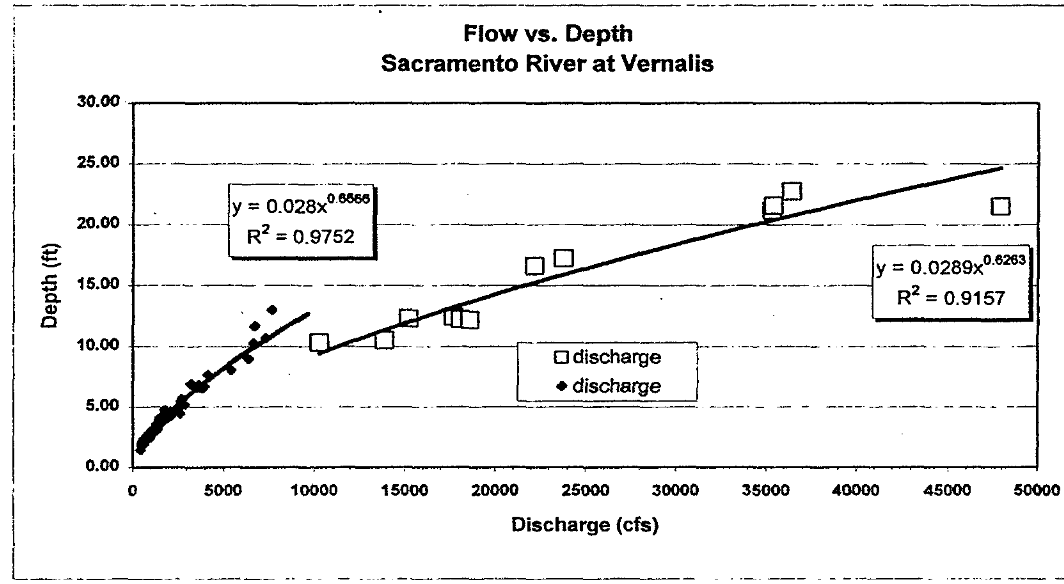

FIGURE S-10b Discharge vs. Average Depth (Calculated, 1988-1997)

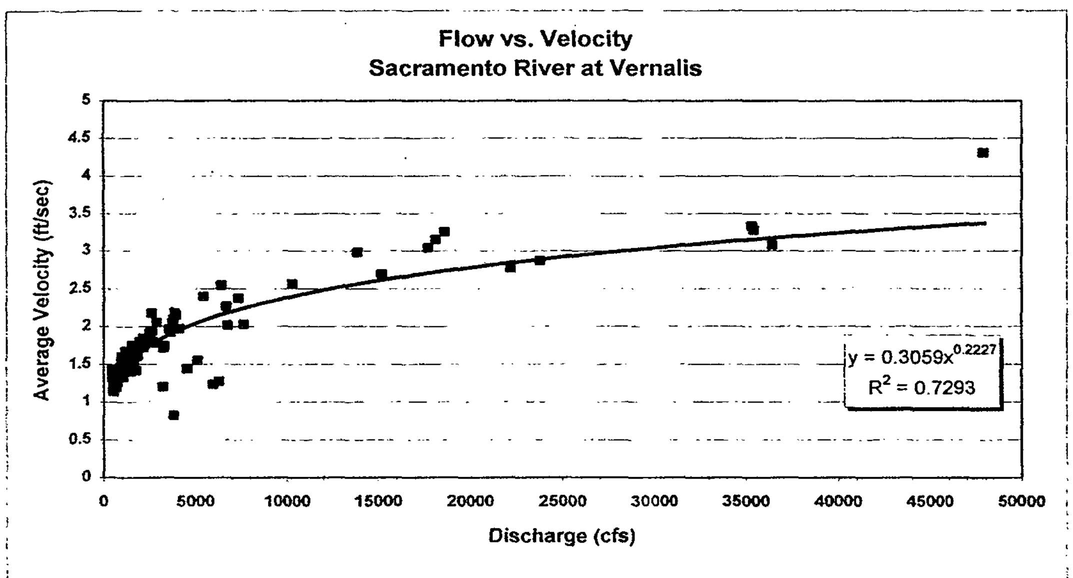

FIGURE S-10c Discharge vs. Average Velocity (Calculated, 1988-1997)

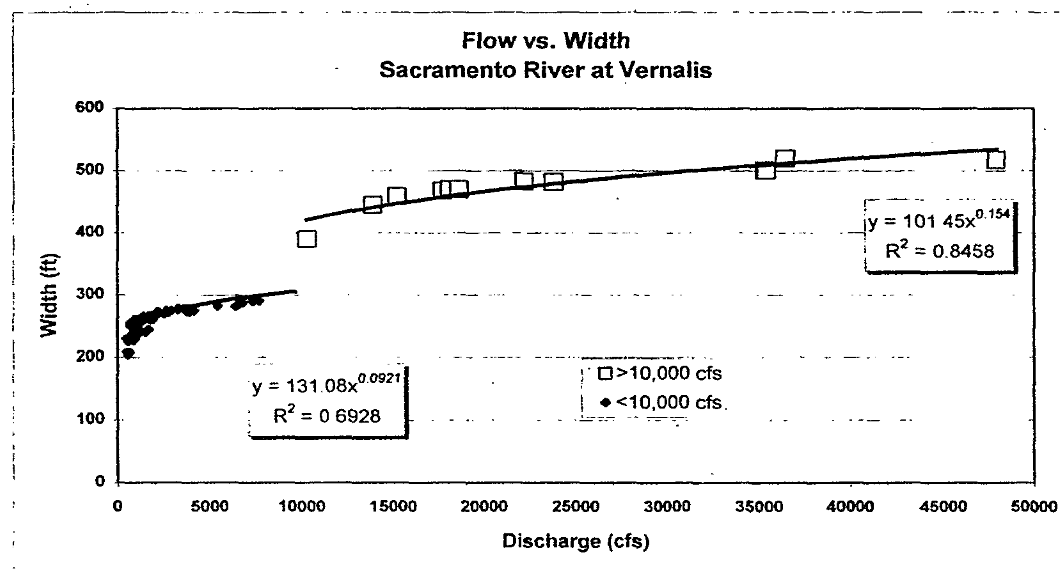

FIGURE S-10d Discharge vs. Top Width (Measured, 1988-1997)

Figure S-10. San Joaquin River at Vernalis: Flow vs. Stage, Depth, Velocity, and Width

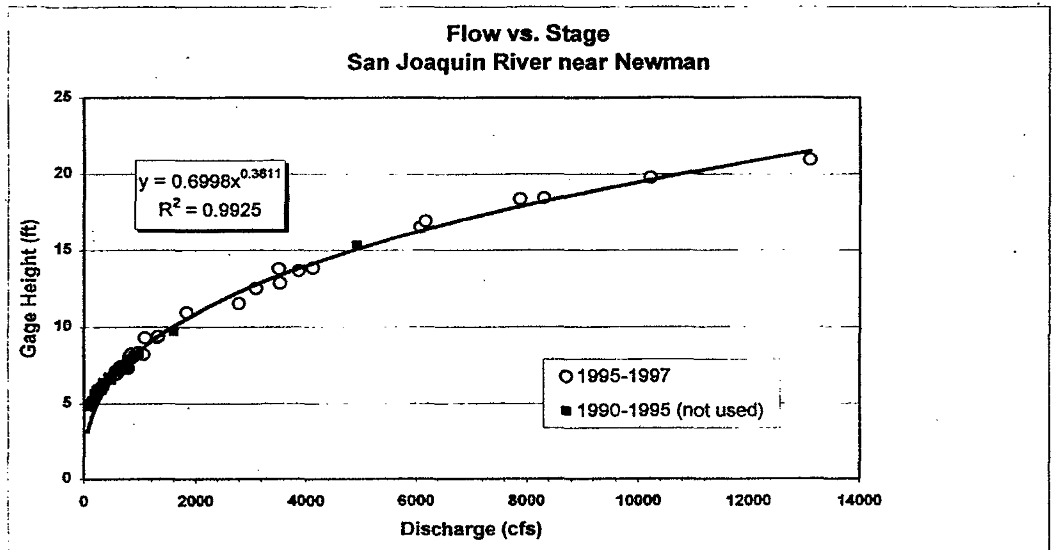

FIGURE S-11a Discharge vs. Gage Height (Measured, 1995-1997)

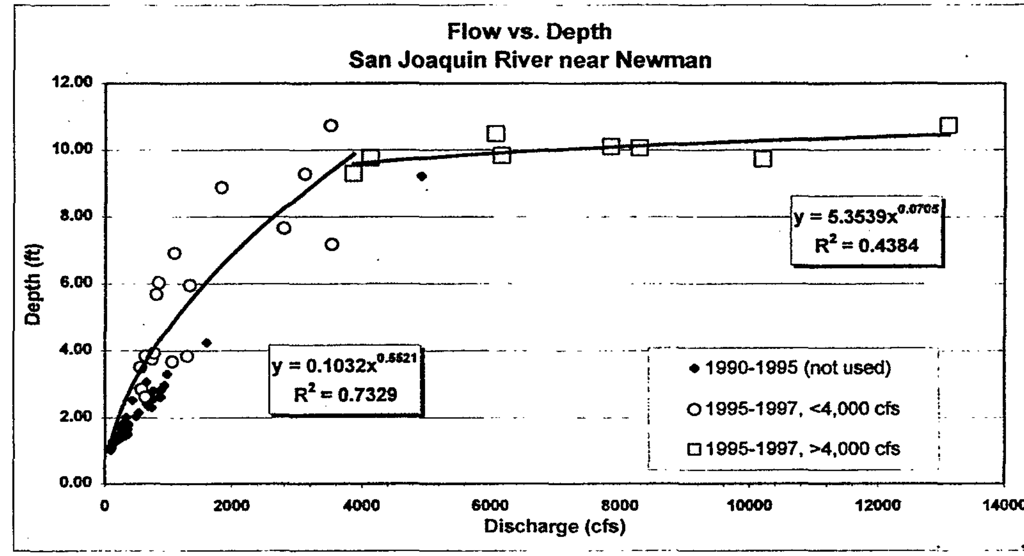

FIGURE S-11b Discharge vs. Average Depth (Calculated, 1995-1997)

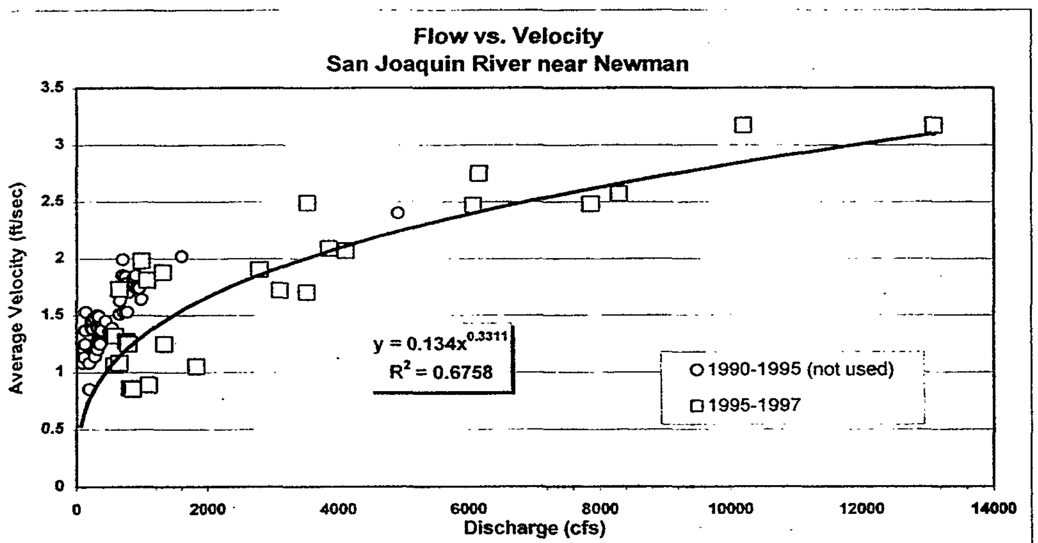

FIGURE S-11c Discharge vs. Average Velocity (Calculated, 1995-1997)

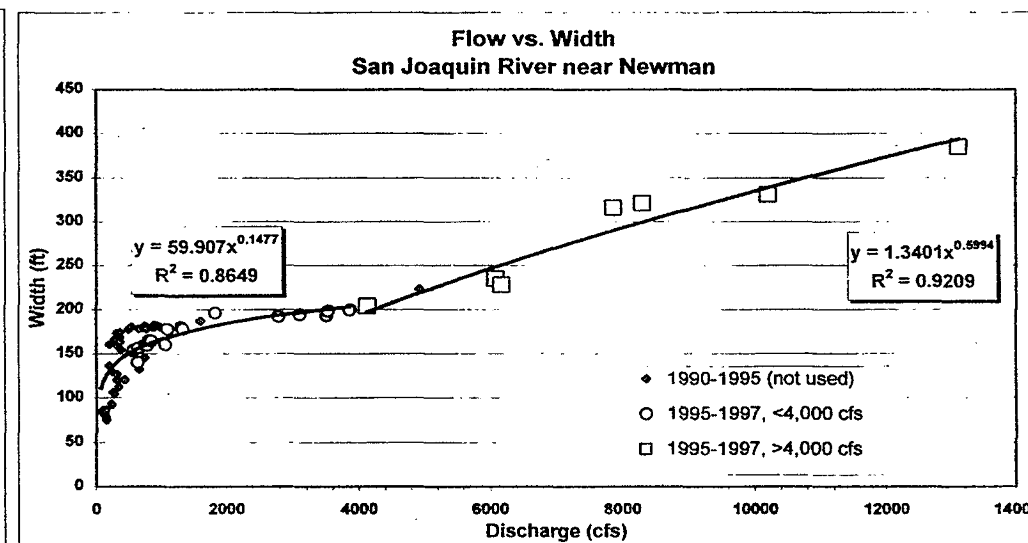

FIGURE S-11d Discharge vs. Top Width (Measured, 1995-1997)

Figure S-11. San Joaquin River near Newman: Flow vs. Stage, Depth, Velocity, and Width

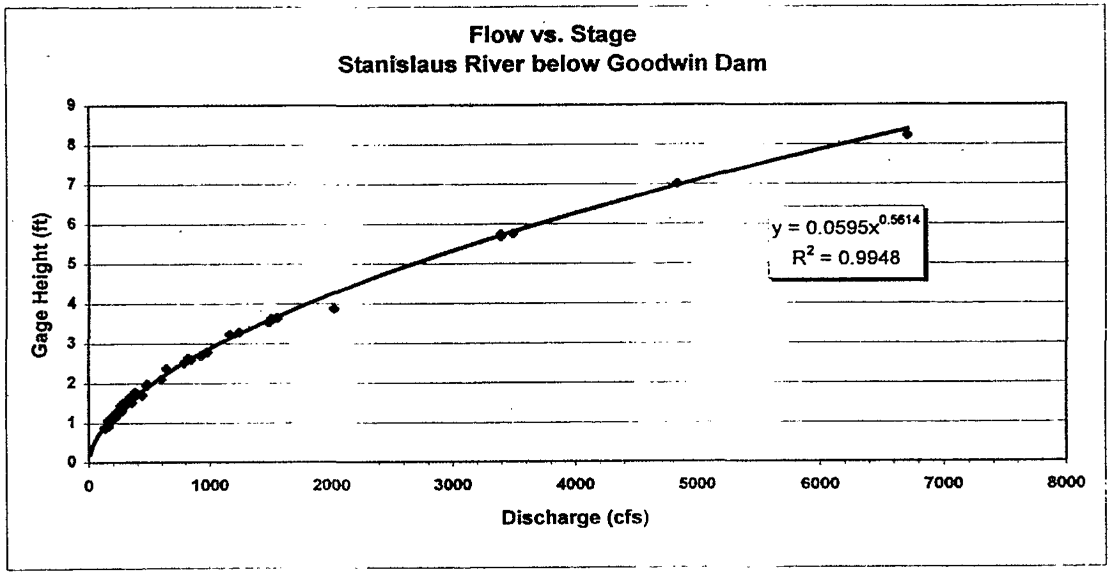

FIGURE S-12a Discharge vs. Gage Height (Measured, 1989-1997)

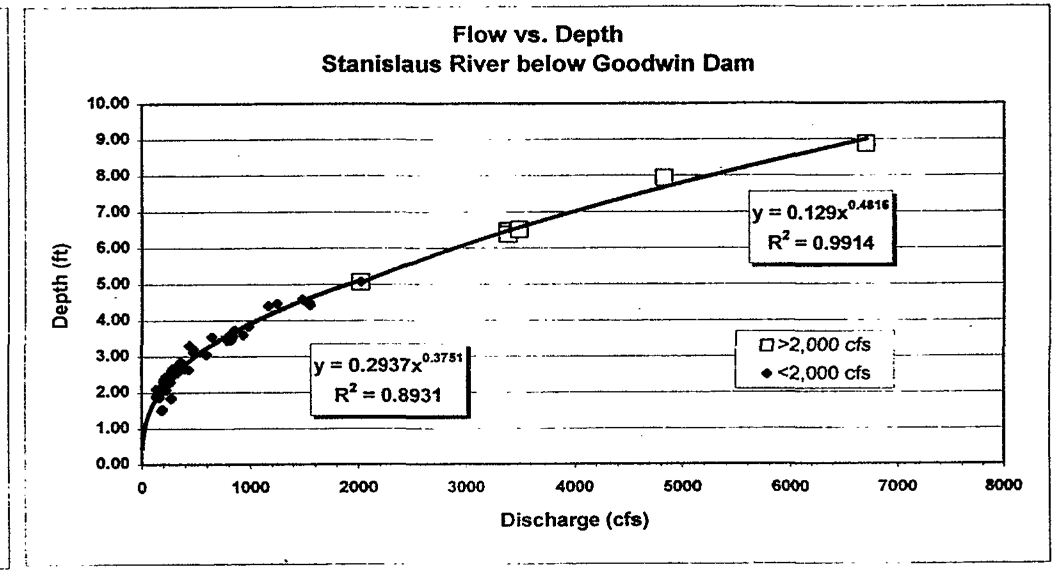

FIGURE S-12b Discharge vs. Average Depth (Calculated, 1989-1997)

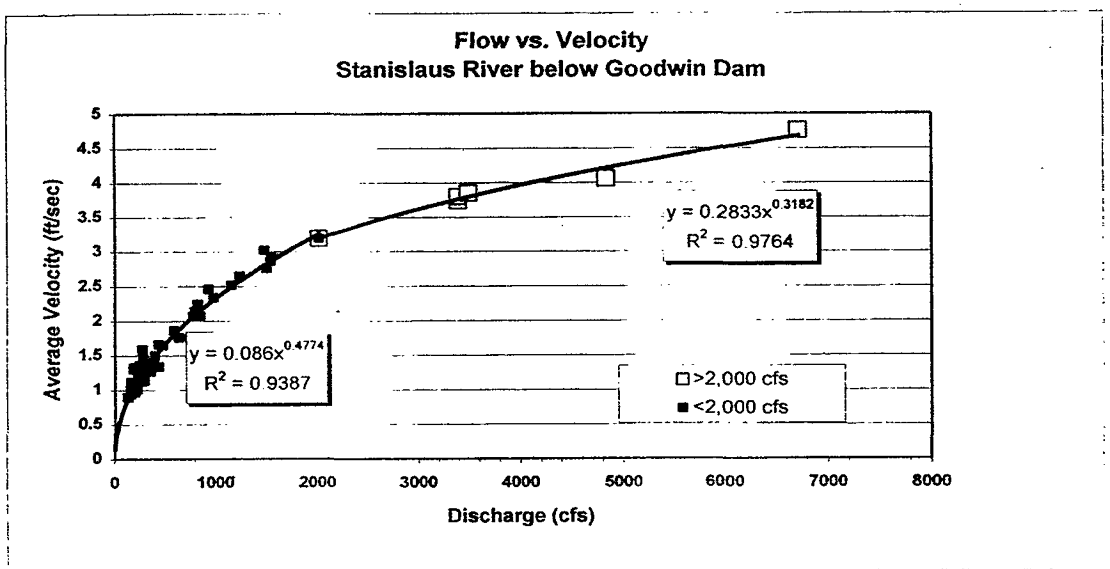

FIGURE S-12c Discharge vs. Average Velocity (Calculated, 1989-1997)

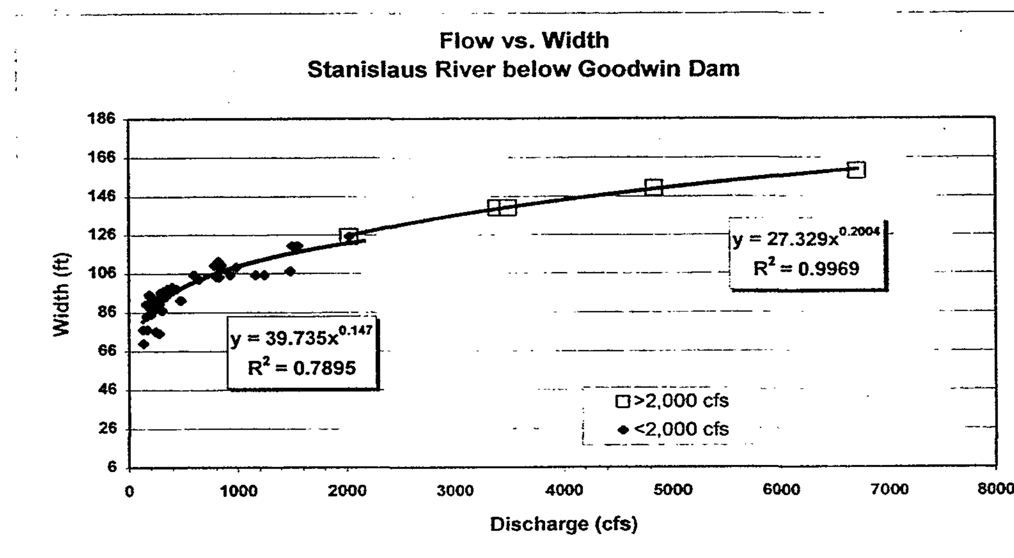

FIGURE S-12d Discharge vs.Top Width (Measured, 1989-1997)

Figure S-12. Stanislaus River below Goodwin Dam: Flow vs. Stage, Depth, Velocity, and Width

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SURFACE WATER RESOURCES

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